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Fast radio bursts

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Abstract

© 2018 Uspekhi Fizicheskikh Nauk, Russian Academy of Sciences. First discovered in 2007, fast radio bursts (FRBs) are highly luminous (10-1-102 Jy), millisecond-scale, highly dispersive single radio pulses whose record high brightness temperatures suggest a nonthermal emission mechanism. As of March 2018, a total of 32 FRBs have been recorded. There is also one repeating source, from which hundreds of bursts have already been detected. The rate of events is estimated to be several thousand per day per sky (disregarding bursts from the repeater), and their isotropic distribution in the sky suggests a likely cosmological origin. While numerous hypotheses have been proposed for FRBs since their discovery, the origin of these transients is not yet known. The most promising models either relate them to burst-type radiation from magnetars (neutron stars powered by the dissipation of their magnetic energy) or consider them analogous to giant pulses from some radio pulsars (strongly magnetized rotating neutron stars). The increasing statistics on the observed bursts and improvements in characterizing the FRB population will allow FRBs to become another tool for probing the intergalactic medium, estimating the cosmological parameters, and testing fundamental physical theories.

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Keywords

Fast radio bursts, Neutron stars, Radio astronomy, Transient sources

References

[1] Cordes J M, Lazio T J W McLaughlin M A New Astron. 48 1459 (2004)
[2] Hyman S D et al. Nature 434 50 (2005)
[3] Roy S et al. Astrophys. J. Lett. III L5 (2010)
[4] Lorimer D R et al. Science 318 777 (2007)
[5] Champion D J et al. Mon. Not. R. Astron. Soc. 460 L30 (2016)
[6] Katz J I Phys. Rev. D 89 103009 (2014)
[7] Fender R et al., in Advancing Astrophysics with the Square Kilometre Array, AASKA14, June 8-13, 2014, Giardini Naxos, Italy
[8] PoS 215 051 (2015)
[9] Kellermann K I, Pauliny-Toth II K Astrophys. J. 155 L71 (1969)
[10] Loeb A, Shvartzvald Y, Maoz D Mon. Not. R. Astron. Soc. 439 L46 (2014)
[11] Cordes J M, McLaughlin M A Astrophys. J. 596 1142 (2003)
[12] Katz J I Astrophys. J. 818 19 (2016)
[13] Xu S, Zhang B Astrophys. J. 832 199 (2016)

[14] Yao J M, Manchester R N, Wang N Astrophys. J. 835 29 (2017)
[15] Lyubarsky Y Astrophys. J. 682 1443 (2008)
[16] Lyubarsky Y, Ostrovska S Astrophys. J. 818 74 (2016)
[17] Postnov K A Phys. Usp. 42 469 (1999)
[18] Usp. Fiz. Nauk 169 545 (1999)
[19] McLaughlin M A et al. Nature 439 817 (2006)
[20] Burke-Spolaor S Proc. Int. Astron. Union 8 (S291) 95 (2013)
[21] Cordes J M, Lazio T J W astro-ph/0207156
[22] Schnitzeler D H F M Mon. Not. R. Astron. Soc. 427 664 (2012)
[23] Keane E F et al. Mon. Not. R. Astron. Soc. 425 L71 (2012)
[24] Thornton D et al. Science 341 53 (2013)
[25] Burke-Spolaor S et al. Astrophys. J. 727 18 (2011)
[26] Kulkarni S R et al. Astrophys. J. 797 70 (2014)
[27] Kocz J et al. Mon. Not. R. Astron. Soc. 420 271 (2012)
[28] Katz J I Astrophys. J. 788 34 (2014)
[29] Petroff E et al. Mon. Not. R. Astron. Soc. 451 3933 (2015)
[30] Petroff E et al. Publ. Astron. Soc. Australia 33 e045 (2016)
[31] Rane A, Lorimer D J. Astrophys. Astron. 38 55 (2017)
[32] Petroff E, arXiv: 1709.02189
[33] Bannister KW et al. Astrophys. J. Lett. 841 L12 (2017)
[34] Farah W et al. Mon. Not. R. Astron. Soc. 478 1209 (2018)
[35] Michilli D et al. Nature 553 182 (2018)
[36] Crawford F et al. Mon. Not. R. Astron. Soc. 460 3370 (2016)
[37] Bhandari S et al. Mon. Not. R. Astron. Soc. 475 1427 (2018)
[38] Petroff E et al. Mon. Not. R. Astron. Soc. 447 246 (2015)
[39] Petroff E et al. Mon. Not. R. Astron. Soc. 469 4465 (2017)
[40] Keane E F et al. Nature 530 453 (2016)
[41] Ravi V et al. Science 354 1249 (2016)
[42] Williams P K G, Berger E Astrophys. J. Lett. 821 L22 (2016)
[43] Johnston S et al. Mon. Not. R. Astron. Soc. 465 2143 (2017)
[44] Giroletti M et al. Astron. Astrophys. 593 L16 (2016)
[45] Yamasaki S, Totani T, Kawanaka N M Mon. Not. R. Astron. Soc. 460 2875(2016)
[46] Xi S-Q et al. Astrophys. J. Lett. 842 L8 (2017)
[47] Palaniswamy D et al. Astrophys. J. 790 63 (2014)
[48] DeLaunay J J et al. Astrophys. J. Lett. 832 L1 (2016)
[49] Coenen T et al. Astron. Astrophys. 570 A60 (2014)
[50] Rowlinson A et al. Mon. Not. R. Astron. Soc. 458 3506 (2016)
[51] Caleb M et al. Mon. Not. R. Astron. Soc. 458 718 (2016)
[52] Burke-Spolaor S et al. Astrophys. J. 826 223 (2016)
[53] Lyutikov M, Burzawa L, Popov S B Mon. Not. R. Astron. Soc. 462 941 (2016)
[54] Rajwade K M, Lorimer D R Mon. Not. R. Astron. Soc. 465 2286 (2017)
[55] Chawla P et al. Astrophys. J. 844 140 (2017)
[56] Foster G et al. Mon. Not. R. Astron. Soc. 474 3847 (2018)
[57] Masui K et al. Nature 528 523 (2015)
[58] Li L-B et al. Res. Astron. Astrophys. 17 6 (2017)
[59] Oppermann N, Connor L D, Pen U-L Mon. Not. R. Astron. Soc. 461 984 (2016)
[60] Ravi V Mon. Not. R. Astron. Soc. Styl 551 (2018); arXiv:1710.08026
[61] Macquart J P, Ekers R D Mon. Not. R. Astron. Soc. 474 1900 (2018)
[62] Lawrence E et al. Astron. J. 154 117 (2017)
[63] Vander Wiel S et al., arXiv:1612.00896
[64] Spitler L G et al. Astrophys. J. 790 101 (2014)

[65] Spitler L G et al. Nature 531 202 (2016)
[66] Chatterjee S et al. Nature 541 58 (2017)
[67] Gajjar V et al. The Astronomer's Telegram (1067) (2017)
[68] Tendulkar S P et al. Astrophys. J. Lett. 834 L7 (2017)
[69] Bassa C G et al. Astrophys. J. Lett. 843 L8 (2017)
[70] Marcote B et al. Astrophys. J. Lett. 834 L8 (2017)
[71] Scholz P et al. Astrophys. J. 846 80 (2017)
[72] Hardy L K et al. Mon. Not. R. Astron. Soc. 472 2800 (2017)
[73] Bird R, for the VERITAS Collab., arXiv:1708.04717
[74] Beloborodov A M Astrophys. J. Lett. 843 L26 (2017)
[75] Metzger B D, Berger E, Margalit B Astrophys. J. 841 14 (2017)
[76] Kashiyama K, Murase K Astrophys. J. Lett. 839 L3 (2017)
[77] Wang F Y, Yu H J. Cosmol. Astropart. Phys. 3 023 (2017)
[78] Katz J I Mon. Not. R. Astron. Soc. 476 1849 (2018)
[79] Cordes J M et al. Astrophys. J. 842 35 (2017)
[80] Palaniswamy D, Li Y, Zhang B Astrophys. J. Lett. 854 L12 (2018)
[81] Katz J I Mod. Phys. Lett. A 31 1630013 (2016)
[82] Vachaspati T Phys. Rev. Lett. 101 (14) 141301 (2008)
[83] Rees M J Nature 266 333 (1977)
[84] Barrau A, Rovelli C, Vidotto F Phys. Rev. D 90 127503 (2014)
[85] Liu T et al. Astrophys. J. 826 82 (2016)
[86] Tuntsov A V Mon. Not. R. Astron. Soc. 441 L26 (2014)
[87] Romero G E, del Valle M V, Vieyro F L Phys. Rev. D 93 023001 (2016)
[88] Mottez F, Zarka P Astron. Astrophys. 569 A86 (2014)
[89] Egorov A E, Postnov K A Astron. Lett. 35 241 (2009)
[90] Zhang B Astrophys. J. Lett. 836 L32 (2017)
[91] Geng J J, Huang Y F Astrophys. J. 809 24 (2015)
[92] Tkachev II JETP Lett. 1011 (2015)
[93] Pis'ma Zh. Eksp. Teor. Fiz. 101 3 (2015)
[94] Iwazaki A Phys. Rev. D 91 023008 (2015)
[95] Pshirkov M S Intern. J. Mod. Phys. D 26 1750068 (2017)
[96] Drago A, Pagliara G Phys. Rev. C 92 045801 (2015)
[97] Alvarez-Castillo D E et al., arXiv: 1506.08645
[98] Shand Z et al. Res. Astron. Astrophys. 16 (5) 011 (2016)
[99] Falcke H, Rezzoila L Astron. Astrophys. 562 A137 (2014)
[100] Ravi V, Lasky P D Mon. Not. R. Astron. Soc. 441 2433 (2014)
[101] Zhang B Astrophys. J. Lett. 780 L21 (2014)
[102] Pshirkov M S, Postnov K A Astrophys. Space Sci. 330 13 (2010)
[103] Lyutikov M Astrophys. J. 768 63 (2013)
[104] Totani T Publ. Astron. Soc. Jpn. 65 L12 (2013)
[105] Wang J S et al. Astrophys. J. Lett. 822 L7 (2016)
[106] Lipunov V M, Panchenko I E Astron. Astrophys. 312 937 (1996)
[107] Postnov K A, Yungelson L R Living Rev. Relat. 17 3 (2014)
[108] Abbott B P et al. Phys. Rev. Lett. 119 161101 (2017)
[109] Abbott B P et al. Astrophys. J. Lett. 848 L12 (2017)
[110] Alexander K D et al. Astrophys. J. Lett. 848 L21 (2017)
[111] Mingarelli C M F, Levin J, Lazio T J W Astrophys. J. Lett. 814 L20 (2015)
[112] Kashiyama K, Ioka K, Mészâros P Astrophys. J. Lett. 776 L39 (2013)
[113] Hankins T H, Eilek J A Astrophys. J. 670 693 (2007)
[114] Pen U L, Connor L Astrophys. J. 807 179 (2015)
[115] Cordes J M, Wasserman I Mon. Not. R. Astron. Soc. 457 232 (2016)

[116] Connor L, Sievers J, Pen U L Mon. Not. R. Astron. Soc. 458 L19 (2016)
[117] Popov S B, Postnov K A, in Evolution of Cosmic Objects Through their Physical Activity, Proc. of the Conf. Dedicated to Viktor Ambartsumian's 100th Anniversary, 15-18 September 2008, Yerevan, Byurakan, Armenia (Eds H A Harutyunian, A M Mickaelian, Y Terzian) (Yerevan: Gitutyun, 2010) p. 129
[118] Piro A L Astrophys. J. Lett. 824 L32 (2016)
[119] Popov S B, Pshirkov M S Mon. Not. R. Astron. Soc. 462 L16 (2016)
[120] Popov S B, Postnov K A, arXiv: 1307.4924
[121] Turolla R, Zane S, Watts A L Rep. Prog. Phys. 78 116901 (2015)
[122] Lyutikov M Astrophys. J. Lett. 580 L65 (2002)
[123] Lyubarsky Y Mon. Not. R. Astron. Soc. 442 L9 (2014)
[124] Murase K, Kashiyama K, Mészâros P Mon. Not. R. Astron. Soc. 461 1498 (2016)
[125] Ghisellini G Mon. Not. R. Astron. Soc. 465 L30 (2017)
[126] Vink J, Bamba A Astrophys. J. Lett. 707 L148 (2009)
[127] Younes G et al. Astrophys. J. 757 39 (2012)
[128] Younes G et al. Astrophys. J. 824 138 (2016)
[129] Safi-Harb S Proc. Int. Astron. Union 291 251 (2013)
[130] Rubio-Herrera E et al. Mon. Not. R. Astron. Soc. 428 2857 (2013)
[131] Tendulkar S P, Kaspi V M, Patel C Astrophys. J. 827 59 (2016)
[132] Akahori T, Ryu D, Gaensler B M Astrophys. J. 824 105 (2016)
[133] Fujita Y et al. Astrophys. J. 834 13 (2017)
[134] Shirasaki M, Kashiyama K, Yoshida N Phys. Rev. D 95 083012 (2017)
[135] Munoz J B et al. Phys. Rev. Lett. 117 091301 (2016)
[136] Eichler D Astrophys. J. 850 159 (2017)
[137] Dolag K et al. Mon. Not. R. Astron. Soc. 451 4277 (2015)
[138] Caleb M et al. Mon. Not. R. Astron. Soc. 458 708 (2016)
[139] Zhou B et al. Phys. Rev. D 89 107303 (2014)
[140] Deng W, Zhang B Astrophys. J. Lett. 783 L35 (2014)
[141] Gao H, Li Z, Zhang B Astrophys. J. 788 189 (2014)
[142] Walters A et al. Astrophys. J. 856 65 (2018) arXiv: 1711.11277
[143] Yu H, Wang F Y Astron. Astrophys. 606 A3 (2017)
[144] Wei J J et al. Phys. Rev. Lett. 115 261101 (2015)
[145] Zhang S-N, arXiv:1601.04558
[146] Tingay S J, Kaplan D L Astrophys. J. Lett. 820 L31 (2016)
[147] Wu X F et al. Astrophys. J. Lett. 822 L15 (2016)
[148] Bonetti L et al. Phys. Lett. B 757 548 (2016)
[149] Bonetti L et al. Phys. Lett. B 768 326 (2017)
[150] Keane E F (SUPERB Collab.), arXiv: 1602.05165
[151] Macquart J P et al., in Advancing Astrophysics with the Square Kilometre Array, AASKA14, June 8-13, 2014, Giardini Naxos, Italy
[152] PoS 215 055 (2015)
[153] Chennamangalam J et al., arXiv:1511.04132
[154] Law C J et al. Astrophys. Suppl. Ser. 2368 (2018) arXiv: 1802.03084
[155] Maan Y, van Leeuwen J, arXiv: 1709.06104
[156] Lyutikov M, Lorimer D R Astrophys. J. Lett. 824 L18 (2016)
[157] Andreoni I, Cooke J, arXiv:1802.01100